Small Business Innovation Research/Small Business Tech Transfer

High Performance Solver for Coupled Cavitation and Fluid-Structure Interaction in Cryogenic Environments, Phase I

Completed Technology Project (2018 - 2019)

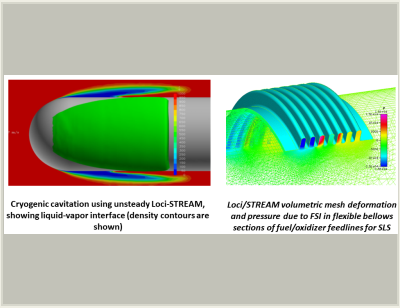
Project Introduction

The innovation proposed here is a high performance, high fidelity simulation capability to enable accurate, fast and robust simulation of coupled cavitation and fluid-structure interaction (FSI) in flows involving cryogenic fluids of interest to NASA (such as LOX, LH2, LCH4 or RP-1). Cavitation and other unsteady flow-induced phenomena in some components of liquid rocket engines as well as testing can induce not only high-cycle fatigue but also structure failure, and possibly extensive damages to these components. The proposed work seeks to deliver a robust computational modeling capability to accurately predict and model the transient fluid structure interaction between cryogenic fluids and immersed components to predict the dynamic loads, frequency response of NASA's test facilities, and to substantially reduce the costs of NASA's test and launch operations. The key features of the proposed work are: (a) Accurate and efficient unsteady cryogenic cavitation simulation methodology, and (b) A robust first principles based fluid-structure interaction (FSI) capability. Both these methodologies will be tightly coupled within the framework of the Loci-STREAM code which is a Computational fluid dynamics (CFD) solver already in use at NASA for a variety of applications. This project seeks to further improve the current cavitation models within Loci-STREAM to achieve production status at NASA for time-accurate simulations of cavitating flows and at the same time integrate a fluid-structure interaction (FSI) methodology into Loci-STREAM. This will involve upgrading the current cavitation models in Loci-STREAM, improving the numerics of the solution algorithm from an efficiency point of view, improving coupling of the cavitation models and the FSI module with Loci-STREAM, and assessing the predictive capability for cases relevant to NASA.

Anticipated Benefits

1. Design of test facility components: resistance temperature detector (RTD) probes, bellows expansion joints.
2. Analysis of cryogenic propellant delivery systems (tanks, runlines), control elements such as LOX control valves.
3. Coupled hydrodynamics, valve timing and scheduling, & cavitation in cryogenic propellant/oxidizer feedlines, and flow devices (venturis, orifices).
4. Behavior of valves, check valves, chokes, etc. during the facility design process.
5. Design of tubopumps in LREs.

1. Coupled cavitation and fluid-structure interaction modeling in liquid turbopumps.
2. Fluid-structure interaction (aeroelastic) modeling in gas turbines.
3. Design of test facility components.
4. Aerodynamic flutter.



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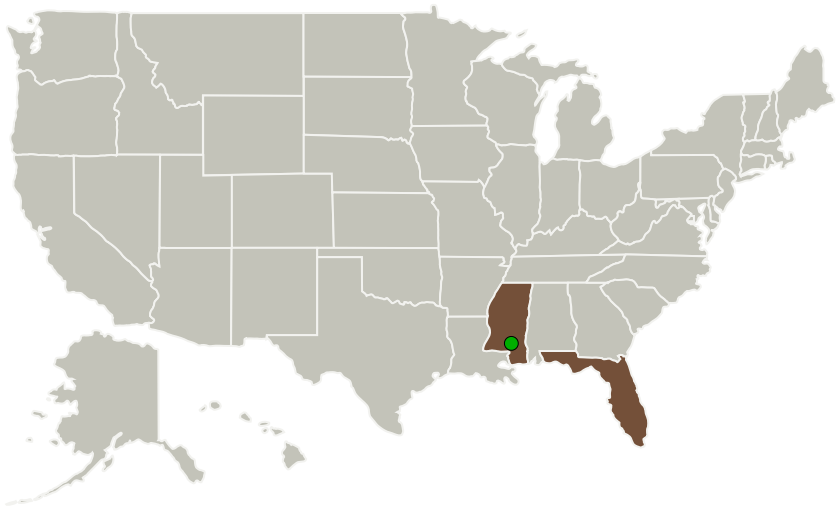
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Streamline Numerics, Inc.	Lead Organization	Industry	Gainesville, Florida
Stennis Space Center(SSC)	Supporting Organization	NASA Center	Stennis Space Center, Mississippi

Primary U.S. Work Locations	
Florida	Mississippi

Project Transitions

July 2018: Project Start

February 2019: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/141079)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Streamline Numerics, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Principal Investigator:

Siddharth S Thakur

Co-Investigator:

Siddharth Thakur

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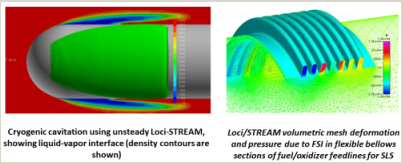
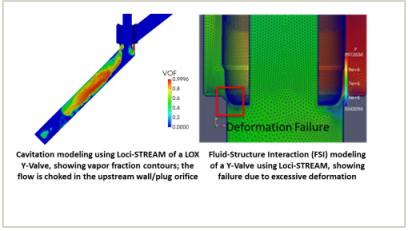
Images



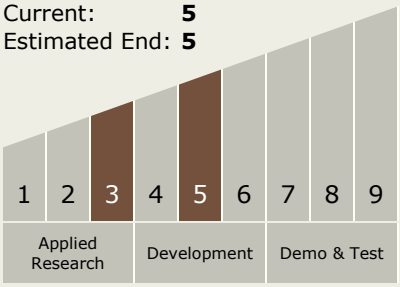
Briefing Chart Image
High Performance Solver for Coupled Cavitation and Fluid-Structure Interaction in Cryogenic Environments, Phase I *(https://techport.nasa.gov/image/134521)*



Final Summary Chart Image
High Performance Solver for Coupled Cavitation and Fluid-Structure Interaction in Cryogenic Environments, Phase I *(https://techport.nasa.gov/image/126143)*

Technology Maturity (TRL)

Start: **3**
Current: **5**
Estimated End: **5**



Technology Areas

Primary:

- TX11 Software, Modeling, Simulation, and Information Processing
  - TX11.4 Information Processing
    - TX11.4.4 Collaborative Science and Engineering

Target Destination

Earth